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# THE SEASONAL INCIDENCE OF SNAKES

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## INTRODUCTION

Few data dealing with the seasonal fluctuations in the occurrence of reptiles are available. Studies of such fluctuations are of great value in estimating the relative importance of ecological factors influencing the activities of ectothermal animals. Moreover, these studies are of practical importance to the medical practitioner who is responsible for the effective treatment of snake-bite, to the commercial collector who must utilize his efforts most profitably, and to the systematic herpetologist who likewise wishes to apply his time and efforts most efficiently, as well as to learn all the details about the animals he studies. Existing information on this subject is primarily the result of investigations concerned with reptiles of the northern latitudes where marked fluctuations exist in temperature and rainfall. Very little is known of the species occurring in those tropical climates where slight variations in temperature and rainfall are the rule. Data for a species of snake living in a tropical climate with little variation in temperature have recently been made available by my colleague, Dr. Harvey Bassler. These will be analyzed in connection with other data derived from studies of snakes in different climates, supplemented with a review of the major sources of published observations on this subject.

It is perhaps unnecessary to point out that these data raise more questions than they answer. Nonetheless, they are of value in pointing to problems that require solution. There is need to stress the obvious fact that the fluctuations in the number of specimens obtained per month do not necessarily indicate variation in population size or in the activity of snakes. It may be related to either or to both. Under favorable conditions, however, more specimens can be obtained at periods of maximum activity than at periods of minimum activity.

Throughout this study the word "temperature" refers to air temperatures. Klauber (1939), in discussing reptile activity in the southwestern United States, has pointed out that "a high temperature in the early spring will not bring out the reptiles before the ground temperature has had time to rise." Cowles and Bogert (1944) have further amplified the subject with respect to the importance and complexity of environmental temperatures in relation to body temperatures and the activities of reptiles. These authors have shown that air temperatures provide only an approximation of the body temperatures that govern the activities of the organism. Unfortunately air temperatures are the only data recorded for many studies previously published, and the observations reported herein are, of necessity, restricted to conclusions based on such information. Despite the imperfections of these data, they do afford an approximate indication of the thermal level of a reptile's environment.

## MATERIAL

The data presented herein are based on 83 well-documented specimens of the snake *Thalerophis richardi nigromarginatus* (= *Leptophis nigromarginatus* of authors) collected in the vicinity of Iquitos, Peru, by Dr. Harvey Bassler of the American Museum of Natural History. I am indebted to Dr. Bassler for the privilege of

examining this material. Dr. Bassler was a resident of Iquitos for 10 years, and he states that the intensity of collecting was virtually the same throughout each year. In the unusually large assemblage of amphibians and reptiles gathered by him, there are sizable numbers of individuals of various species recorded for each month of the year. Therefore a minimal effect from seasonal fluctuations in the human activity associated with the collection of the material is indicated.

## SEASONAL INCIDENCE OF *THALEROPHIS RICHARDI NIGROMARGINATUS*

The data are shown graphically in figure 1 and are summarized in table 1 together with the climatic data for Iquitos, Peru.[1] The most prominent features are the increase in the numbers of these snakes captured in March and the absence of any uniformity in the numbers recorded for the different months. Aside from chance, inherent in small samples, it might have been expected on theoretical grounds that in a climate with relatively uniform temperatures and no dry season, the monthly occurrence of snakes would be virtually constant. Examination of the detailed climatic data for Iquitos reveals the fallacy of this supposition; whereas the mean monthly temperature varies relatively little (2.4° C.), there is a pronounced (190 mm.) monthly variation in rainfall, despite the absence of a dry season. The maximum monthly rainfall occurs in March and may be associated in some manner with the peak in occurrence of the snakes.

Direct comparison of the monthly variations in rainfall with the monthly fluctuations in number of specimens collected casts doubt on any direct correlation between the two. For example, the rainfall increases gradually to the March maximum, whereas there is a sharp increase in number of specimens recorded for March. Furthermore, 14 per cent of the total number of females were collected during the month with the least rainfall. The discrepancies apparent from this comparison of the monthly fluctuations in snakes recorded and the monthly rainfall record may result from the atypical distribution of the published rainfall observations, as pointed out by Dr. Bassler. The sharp increase in the number of snakes recorded in March may be closely related to the increased rainfall of March that marks the termination of what is recognized locally as the "Verano del Niño."

While the data do not lend support to a direct correlation between monthly occurrence of this snake and the monthly variation in rainfall, there are several possible indirect influences. One of these is the widespread flooding that causes concentrations on the available land. The vicinity of Iquitos is subjected to severe floods during the months of maximum rainfall, and the accompanying restriction in the land surface available may make it much easier to collect at this time than when the river is low. A study of the fluctuations of the Amazon River at Iquitos has been published by José Gonzáles Iglesias (1940). This author shows that the flood peak is

[1] The only published monthly climatic data that I have been able to locate for this locality are those reported by Knoch (1930). Unfortunately, these cover a period of less than two years and therefore may not be representative of the mean monthly variations. Dr. Bassler made careful rain gauge observations for an extended period. He informs me (*in litt.*) that the rainfall data of Knoch are not typical for the locality. He states that at Iquitos there is usually almost or quite as little rainfall during December, January, and February as there is in June, July, and August. The former months are known locally as "Verano del Niño." In March, April, and May there is somewhat more precipitation than there is in September, October, and November.

After this paper was completed Dr. Bassler was able to obtain his detailed data for the rainfall of the years 1927, 1928, and 1929, and kindly forwarded them for my use. In several instances the monthly rainfall varies considerably for the three years. Dr. Bassler states that "Twice during my residence of 10 years in Iquitos there was *not any rainfall whatever* in the month of February whereas in 1928, February happened to be the rainiest month of the year. In spite of this however our *mean* represents the picture very well." The mean monthly data for the three years are as follows (in millimeters):

| Jan. | Feb. | Mar. | Apr. | May | June |
|---|---|---|---|---|---|
| 160.0 | 203.2 | 266.7 | 276.9 | 261.6 | 147.3 |
| **July** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** |
| 165.1 | 177.8 | 154.9 | 218.4 | 304.8 | 121.9 |

The relationship between the monthly rainfall and the number of snakes collected per month is less apparent from these rainfall figures for the three years recorded by Dr. Bassler. The extent of the variation in monthly rainfall observed at Iquitos indicates that the precise effect of the rainfall on the number of snakes collected can be determined only when sufficient data are available to permit a direct comparison of these two on a month by month basis.

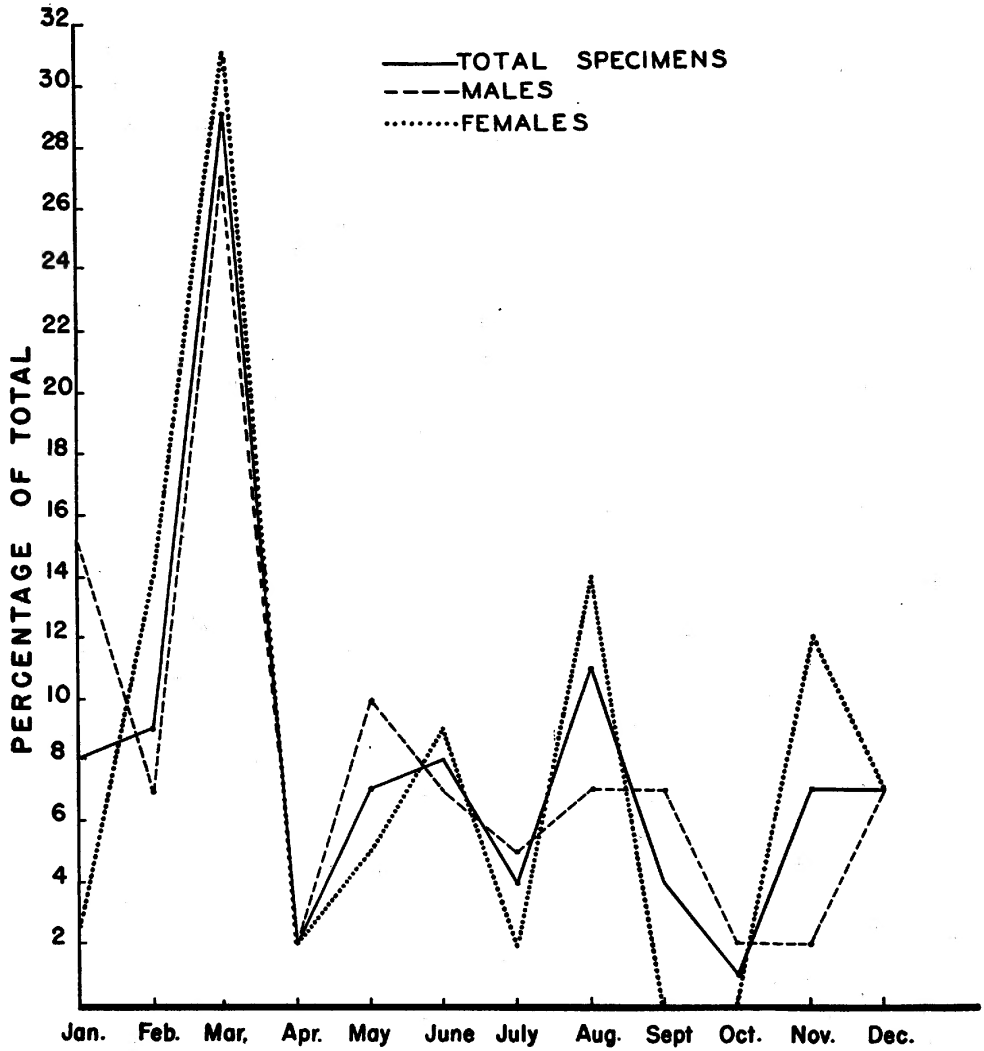


Fig. 1. Monthly variation in collections of *Thalerophis richardi nigromarginatus* in the vicinity of Iquitos, Peru.

reached in May and that the lowest level occurs in September. Neither of these extremes is correlated with unusual fluctuations in occurrence of the snakes. However, Iglesias' data show that from January through June the river is above the mean yearly level, whereas it is below this level from July to the end of December. Two-thirds of the specimens were collected during the months when the river was above the yearly mean. The high level of the river may have some influence on the occurrence of the snakes, but it cannot be either the most important or the only factor involved. If it were the controlling factor, the peak in number of snakes should occur in May rather than in March.

Another indirect influence of the rainfall lies in the relative abundance of the animals utilized as food by *T. r. nigromarginatus*. The diet of this species is nearly restricted to frogs of the family Hylidae. These frogs are known to congregate in breeding groups during the periods of heavy rainfall, and their maximum breeding activity may reach a peak correspond-

TABLE 1

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total specimens collected (percentage in parentheses) | 7 (8%) | 9 (11%) | 24 (29%) | 2 (2%) | 6 (7%) | 7 (8%) | 3 (4%) | 9 (11%) | 3 (4%) | 1 (1%) | 6 (7%) | 6 (7%) |
| Males collected (percentage in parentheses) | 6 (15%) | 3 (7%) | 11 (27%) | 1 (2%) | 4 (10%) | 3 (7%) | 2 (5%) | 3 (7%) | 3 (7%) | 1 (2%) | 1 (2%) | 3 (7%) |
| Females collected (percentage in parentheses) | 1 (2%) | 6 (14%) | 13 (31%) | 1 (2%) | 2 (5%) | 4 (9%) | 1 (2%) | 6 (14%) | 0 | 0 | 5 (12%) | 3 (7%) |
| Mean monthly rainfall (in millimeters) | 255 | 269 | 305 | 167 | 249 | 186 | 164 | 115 | 224 | 181 | 217 | 286 |
| Mean monthly temperature (in degrees Centigrade) | 25.3 | 25.7 | 24.6 | 25.0 | 24.2 | 23.5 | 23.4 | 24.6 | 24.6 | 25.1 | 25.8 | 25.5 |

Total annual rainfall, 2623.0 mm.; average annual temperature, 24.8° C.

ing to the period of maximum rainfall. During the breeding period the frogs are abundant and active in the vicinity of the breeding sites. The snakes, attracted by the more plentiful food supply, are abroad in increased numbers and hence encountered more frequently by collectors. The only observations pertaining to the frogs that make up the food of these snakes are based on the examination of stomach contents. It is fortuitous whether snakes are collected immediately after eating (with identifiable stomach contents) or whether they are collected prior to eating (with an empty stomach). For months represented by six or more specimens, half of those collected in November and March and two-thirds of those collected in December contain hylid frogs. The only indication of the breeding time in the frogs serving as food is that specimens with ripe eggs have been observed in snakes collected in March and December.

Another factor that must be considered in any effort to determine the cause of the greater number of snakes taken in March is their time of mating and oviposition. No direct information is available on the breeding period of *T. r. nigromarginatus.* Figure 2 illustrates the total number of females collected per month, together with the number of females per month that possessed developing eggs. Ovarian follicles as large as 6 mm. in length were observed in immature individuals. Hence to avoid inclusion of data from females with immature eggs, a size of 10 mm. was arbitrarily selected as the minimum egg size considered. The maximum size observed was a length of 28 mm. Females with eggs 10 mm. or larger are present in snakes taken in every month except April, September, and October. No females are represented for these last two months, and only a single female is present in the April collection. Thus on the basis of these data there is no indication of a restricted breeding season. Ova approximately 25 mm. in length supposedly are close to maturity and oviposition. Eggs of this size or greater have been observed in females collected in the following months: January, March, May, June, and December.

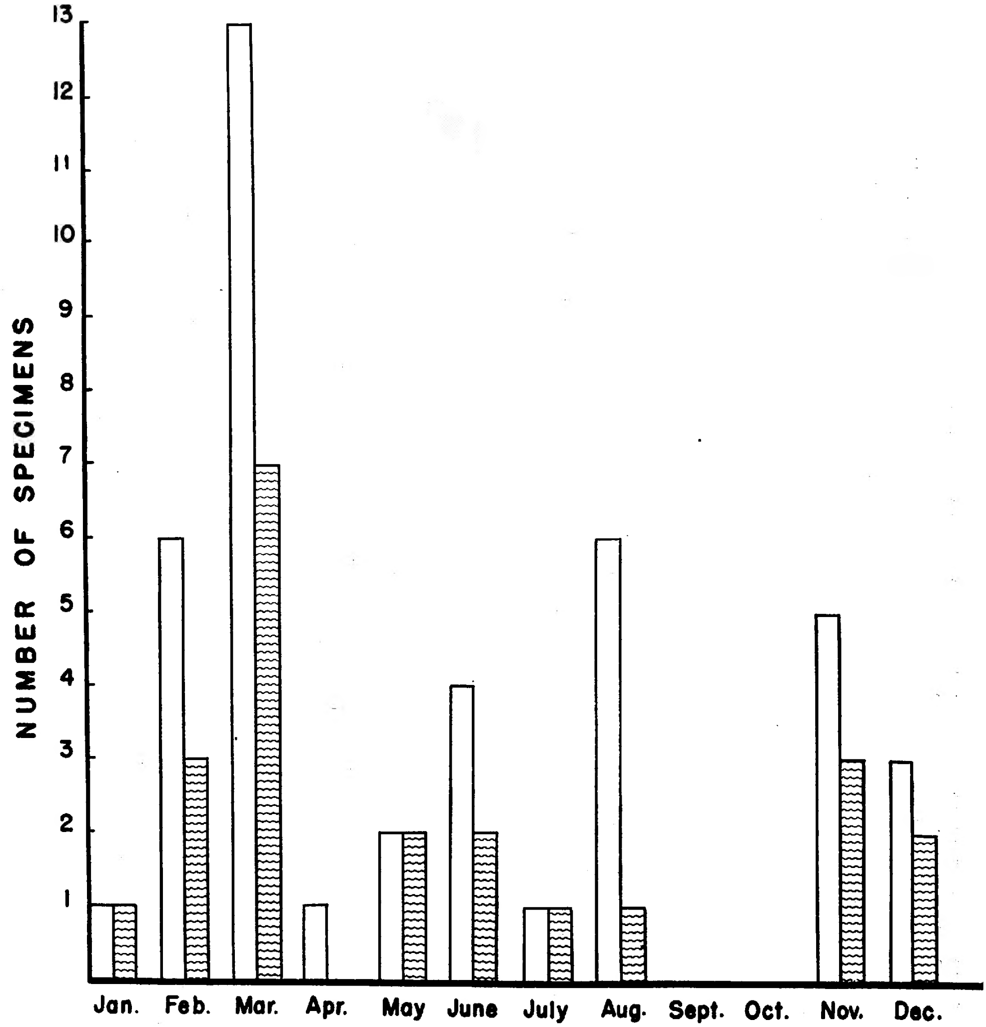


Fig. 2. Histogram showing variation in monthly collections of females (unshaded) and of females that contained developing eggs exceeding 9.9 n.m. in length (shaded) of *Thalerophis richardi nigromarginatus* in the vicinity of Iquitos, Peru.

It is difficult to evaluate these few observations on reproduction because in this species little is known concerning the frequency of mating. It has not been ascertained whether a single insemination is sufficient for the fertilization of clutches over a period of years (as has been shown for other species), and the length of the gestation period, as well as the length of the post-oviposition development, is unknown. Kopstein (1938), in his study of reproduction in Javanese reptiles, noted that fewest eggs are laid in the dry months and that "the majority of the ovipositions in Central Java are in the wet monsoons."

Kopstein's studies were made in a monsoon climate characterized by a marked dry season and a sharp increase in rainfall with the beginning of the monsoons. No similar dry season occurs at Iquitos, Peru. The lowest monthly rainfall is 115 mm. in August. Of six females collected during that month, none has any eggs larger than 10 mm. in length. This may be an indication that here, too, fewer eggs are produced in the months of less rainfall, but

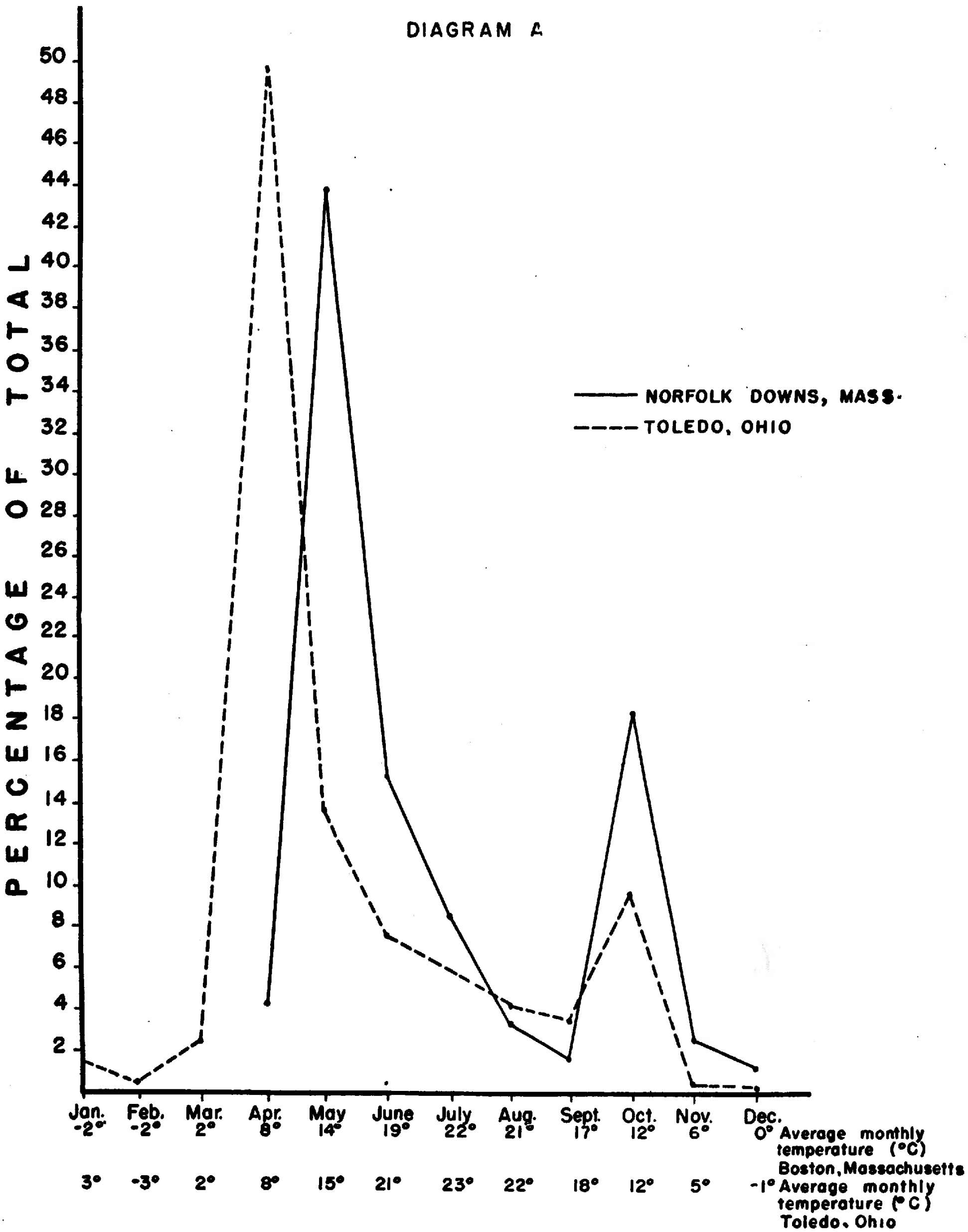
DIAGRAM A
PERCENTAGE OF TOTAL
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
NORFOLK DOWNS, MASS.
TOLEDO, OHIO
Jan. -2°
Feb. -2°
Mar. 2°
Apr. 8°
May 14°
June 19°
July 22°
Aug. 21°
Sept. 17°
Oct. 12°
Nov. 6°
Dec. 0°
Average monthly temperature (°C) Boston, Massachusetts
3° -3° 2° 8° 15° 21° 23° 22° 18° 12° 5° -1°
Average monthly temperature (°C) Toledo, Ohio

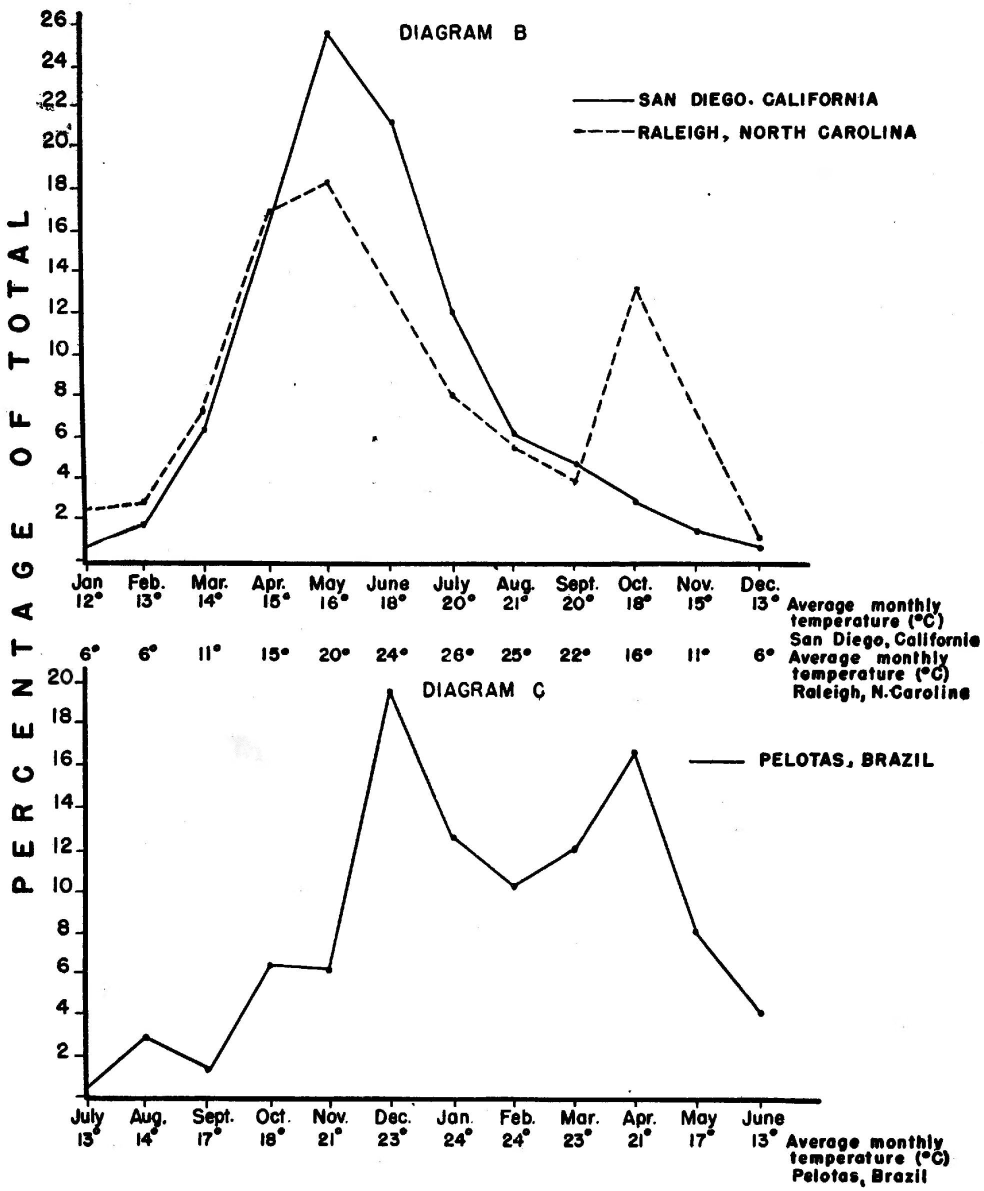


Fig. 3 (this page and opposite). Diagrams illustrating the seasonal incidence of snakes at five different geographical localities, with mean monthly temperatures for each location. Note that in diagram C the months are arranged in sequence beginning with July since this locality is in the Southern Hemisphere.

the data are too limited to establish this. For the series of *nigromarginatus* no marked monthly restriction either of mating or of oviposition that might result in pronounced peaks of occurrence is indicated, although periodic variation in the frequency of these activities doubtless exists.

An inherent physiological cycle of activity conceivably might be a factor reflected in the seasonal incidence. The genus is derived from racer-like colubrine stock, the ancestors of which were presumably evolved in North America. As pointed out below, all of the studies dealing with northern temperate forms illustrate a major peak in the spring months, but not so early as March. There is little evidence to support the view that the March peak in *nigromarginatus* is due to any ancestral physiological trait.

Finally a potential influence is that of human activity. It might be demonstrable that more men were engaged in collecting during the time when the major peak was attained, or that collecting activities varied sufficiently during that time to expose greater numbers of the snakes. Concerning these possibilities I have the statement of Dr. Bassler who believes that there was no variation in human activity that could explain this peak.

## REVIEW OF PUBLISHED DATA

In order to analyze the data for *nigromarginatus*, it is instructive to compare them with the observations available in the literature. There are numerous references to the more prominent aspects of the seasonal fluctuations of snakes. These are usually incidental to other subject matter, but they may constitute the central theme of a particular article on hibernation (Ruthling, 1915; Werner, 1927) or on estivation (Werner, 1891; Schmalz, 1911). Only a few authors have presented data covering the entire period of activity in the area where the observations were made. Because of the limitations in such data, only crude comparisons can be made, and only the broader trends can be noted.

The most detailed and prolonged observations are those of Klauber (especially 1924, 1926, 1931, and 1939) on species of the arid southwestern United States, mainly San Diego County, California. Similar studies on a smaller scale have been reported for other parts of the United States by Brimley (1925), by Conant (1938), and by Loveridge (1927). Volsøe's (1944) detailed comments on the seasonal incidence of *Vipera berus* in Denmark are included as part of his thorough study of the male reproductive organs in that species. Since his data include large numbers of specimens dug out of hibernation dens, the figures for monthly percentages are not comparable to those of the preceding authors. Lindberg (1932) supplies data for the monthly distribution of 434 specimens, representing 19 species, killed between August 19, 1929, and November 1, 1931, along a 203-mile stretch of railroad in India. This railroad is situated on the southwestern section of the Deccan Plateau and includes altitudes between 1600 and 2200 feet above sea level. Consequently marked differences in climatic conditions might occur in various portions of the area involved. Magalhães (1922) records the number of venomous snakes sent to the Instituto de Hygiene at Pelotas, Rio Grande do Sul, Brazil, between March, 1918, and May, 1921. The vast majority of these snakes probably came from the vicinity of Pelotas.

The data presented by these authors, with the exception of those recorded by Lindberg (*op. cit.*) and Volsøe (*op. cit.*), are shown graphically in figure 3. The data presented by Loveridge (*op. cit.*) are included for comparative purposes, although they do not cover the entire year. In diagram C of this figure the months are arranged in sequence beginning with July rather than January in order to make the data from this locality in the Southern Hemisphere more readily comparable to those from the other areas by placing the warmer months for all regions in the same relative positions on the graphs.

The presentation of these data in three

separate diagrams facilitates comparison of them and permits a grouping of the data according to localities within similar major climatic categories.[1] The data in diagram A represent localities possessing "Humid Continental Climates," whereas those in diagrams B and C represent localities having "Subtropical Climates." Blair's (*op. cit.*) definitions of the climate of each locality are given below in abbreviated form and with temperatures and rainfall expressed in metric equivalents of the original.

Toledo, Ohio: WARM HUMID CONTINENTAL CLIMATE

Mean temperatures: coldest month below 6° C.; none to three months below 0° C.; six to nine months above 10° C. Growing season 140 to 220 days; rainfall mostly between 508 and 1016 mm. with summer maximum.

Norfolk Downs, Massachusetts: MODIFIED HUMID CONTINENTAL CLIMATE

Some marine influence; colder summers and less severe winters; mean temperature of five to seven months above 10° C.; none to four months below 0° C.; fairly even distribution of precipitation through the year, with heavy winter snows.

Raleigh, North Carolina: HUMID SUBTROPICAL CLIMATE

Pelotas, Brazil: HUMID SUBTROPICAL CLIMATE

Rainfall moderate to heavy with rain at all seasons, usually a maximum in summer; mean temperature of coldest month above 6° C. but below 18° C.; nine to 12 months above 10° C.; occasional freezing temperatures; growing season 220 days or more.

San Diego, California: DRY SUBTROPICAL (MEDITERRANEAN) CLIMATE

Subhumid; annual rainfall typically between 508 and 762 mm. but some areas have less than 508 mm. and a few more than 762 mm. A distinguishing characteristic is that the maximum rainfall is in winter; the summers are dry, often rainless for two or three months; rainfall is cyclonic; mean temperature of coldest month above 6° C. but below 18° C.; freezing temperatures occur some years but growth is normally continuous; hot summers, mild winters, high percentage of sunshine.

Figure 3 reveals similarities as well as differences between the profiles of monthly incidence for the localities shown. In all of the graphs there is a period of low incidence during the colder months of the year when the snakes customarily are in hibernation. This period is followed by a sharp increase in numbers during the spring months when the temperatures have risen sufficiently to permit emergence from hibernation. This marked increase is termed the spring peak of abundance. Then there is an almost equally sharp decline as the monthly temperatures increase, and in four of the five sets of data there is a smaller secondary increase in the fall.

Differences are to be noted in the nature of the peaks in the spring, especially in the suddenness of the increase, its duration, and in the slope of the decline. Additional differences may occur in the presence or absence of a peak of abundance in the fall and in the extent of the decrease during the warm weather.

At Norfolk Downs and Toledo, the two localities with the shortest growing season and with the greatest annual range in temperature, the spring peaks are extremely sharp and of short duration, with more than 40 per cent of the annual total recorded in a single month. The decline of the spring peak is not quite so abrupt as its appearance. The minor peaks in the fall are equally short in duration and as sharp in outline as those of spring, but of much less prominence. The three subtropical climates exhibit more gradual, lower, and more prolonged spring peaks than those of the colder climates. The graph of the data from San Diego illustrates the highest spring peak of these three, and is the only one that shows no secondary peak in the fall months for the data covering all species. The decline in numbers during the warmer months is less pronounced at Pelotas than at any other locality and the two peaks are almost equal in size.

## DISCUSSION

Numerous factors contributing to the fluctuations in numbers of specimens have been listed. Temperature appears to be the most important single environmental factor limiting the activities of the ectothermal animals under consideration, for

[1] For this purpose the climatic classification of Blair (1942) has been employed.

each species can be active only within a particular range of temperatures. When body temperatures drop below this range hibernation is imperative if death is to be avoided. Similarly, temperatures above the maximum tolerated bring about estivation in protected situations. Within the range of compatible temperatures other environmental factors may become effective. But it is primarily the decrease in the temperatures of the air and the substratum, as well as the available solar heat, that produces the low incidence of snakes during the colder months of the year. The length of the hibernation period depends upon the prevalence of low temperatures, and its termination depends upon a sufficient rise in the thermal level to permit the snakes to become active.

Volsøe (*op. cit.*) has carefully analyzed the factors influencing hibernation in *Vipera berus* in Denmark. He states, "Probably no single climatic component is responsible for the duration of the hibernation, but rather the combined action of several factors. The maximum temperature of the day and the daily duration of the sunshine are the factors which first suggest themselves. In the years 1937 to 1942 the first appearance of the Vipers in the spring took place on the first sunny days after the maximum [air] temperature had reached 8° C." Concerning the onset of hibernation in the fall, this same author observes, "that hibernation begins at about the same temperature conditions which terminate it in the spring, i.e., when the maximum temperature of the day sinks below about 8° C., or perhaps earlier, at about 9°–10°, owing to the cloudy weather which prevails in the autumn."

The termination and onset of hibernation will vary slightly for different species, depending in large measure on the temperature preferences of the species involved. This species difference doubtless affects the occurrence of the spring peak. Brimley (*op. cit.*), Conant (*op. cit.*), Klauber (1931), and Herter (1940) have pointed out that there are "early" and "late" species on the basis of their activity.

Whereas the temperature of the environment, with all its complexities, appears to be the controlling factor in terminating hibernation, numerous phenomena contribute to the formation of the spring peaks. These possibly include the following: basking in the sun during the spring, frequently in aggregations around denning sites in the case of those species that hibernate in groups; mating activity, which occurs at this time in most species; increased appetite for food following hibernation; lack of adequate cover because of incomplete development of foliage; and an increase in human activity with the result that more snakes are seen or collected. The phenomena listed are in themselves dependent in large measure upon the influence of temperature. It is highly significant, as pointed out by Conant (*op. cit.*), that the spring and fall peaks occur at nearly the same average monthly temperature. In the four sets of data that indicate a peak in the fall the difference in mean average monthly temperatures between the month of the spring peak and of the fall peak is 2° to 4° C.

The mean temperatures recorded for months during which the spring peaks occur vary from 8° to 23° C. The two lowest temperatures occur at the localities in the colder climatic types, whereas the maximum temperature occurs at the locality having the highest annual temperature. The effect of rainfall varies with the temperature prevailing at the time of the rain. For example, Conant (*op. cit.*) and Klauber (1931) have noted that rain has a detrimental effect in the early spring when temperatures are near the minimum for a snake's activity, primarily owing to the accompanying drop of the air and ground temperatures. On the other hand, summer and fall rains seem essential in preventing or terminating summer drought, or in lowering excessively high temperatures that result in poor snake collecting. Moreover, the clouds accompanying the rains may reduce solar radiation sufficiently to permit some species to emerge. The data reported by Lindberg (*op. cit.*) indicate a marked increase in the number of snakes following the onset of the rains accompanying the monsoons. Keays (1930) states that pythons appear each

year in considerable numbers in India during the rainy season and disappear at the end of the monsoons.

The decrease in the number of specimens following the peak of the spring months may be due in part to the rise in temperatures during the summer months. However, the lowest numbers of snakes are recorded after, and not coincidental with, the highest monthly temperature, but this may be due to the lag in substratum temperatures. Klauber has shown definitely that temperature alone does not cause the decrease in San Diego County. Additional factors that may contribute to the reduction in numbers observed are: (1) satisfaction of the increased requirements of food following hibernation; (2) completion of mating activities; (3) increased solar heat and its deterrent effect on prolonged basking; (4) change from diurnal to crepuscular or nocturnal habits; (5) increase in protective cover with fully developed foliage on plants; and (6) estivation during periods of high temperatures and low relative humidity. Klauber has observed a difference between the sexes in seasonal activity, with males predominating in most rattlesnake collections, except those made just prior to hibernation at which time the sexes were equal. He suggests that the males range abroad more carelessly and that probably the females remain in concealment when heavy with eggs. Volsøe (*op. cit.*) records a predominance of female *Vipera berus* for the months of May through September, although predominance of males in the spring and fall is sufficient to give a slightly greater number of males than females for the yearly total.

In the studies made in the northern latitudes the minor secondary peak in the fall seems to be due to the recurrence of temperatures similar to those recorded during the time of the spring peak. Additional factors that may influence the increase in numbers recorded in the fall are: (1) the return to the dens in the case of those species that hibernate in groups; (2) decrease in effective solar heat, with a resumption of basking; (3) fall mating in a few species: and (4) the appearance of the young of the year. The only study in which a fall peak was not observed is that made by Klauber (*op. cit.*). Although there is no fall peak in his study for the graph showing all species, there is a secondary fall peak in a few species in the San Diego County region. Concerning this, Klauber states, "For all species combined this secondary peak appears rather as a leveling out of the curve before the decline to the minimum in winter."

One of the drawbacks in this review of published studies for comparative purposes lies in the fact that the data considered are for all species at a given locality. Where data are available for individual species, differences apparently do exist between species. As mentioned above, "early" and "late" species have been distinguished on the basis of a difference in seasonal incidence, and Klauber's graph (1931, fig. 1) shows differences in the curves even though peaks for various species occur in the same month. There is a great need for detailed data pertaining to individual species at different geographical localities throughout the species range. It might be desirable to compare the data for *Thalerophis richardi nigromarginatus* with those derived from the most closely related species from each locality. This method was tested, and the results do not differ appreciably from those where all species were included. In other words, the relative frequencies of occurrence of species most closely related to *Thalerophis* conform to the average for a given locality. One graph, based on the data from Pelotas, Brazil, illustrates the incidence of venomous species only, and may depict a situation somewhat different from that for the total species at that locality.

In this connection, it is worth while to graph the data for the monthly occurrence of venomous snake bites in the United States published by Hutchison (1929, 1930). The results are shown in figure 4. It is highly interesting to note that the maximum number of snake bites occurs at a later date than the maximum number of snakes in the other graphs; it actually occurs when those numbers are decreasing. This difference might be attributed to sev-

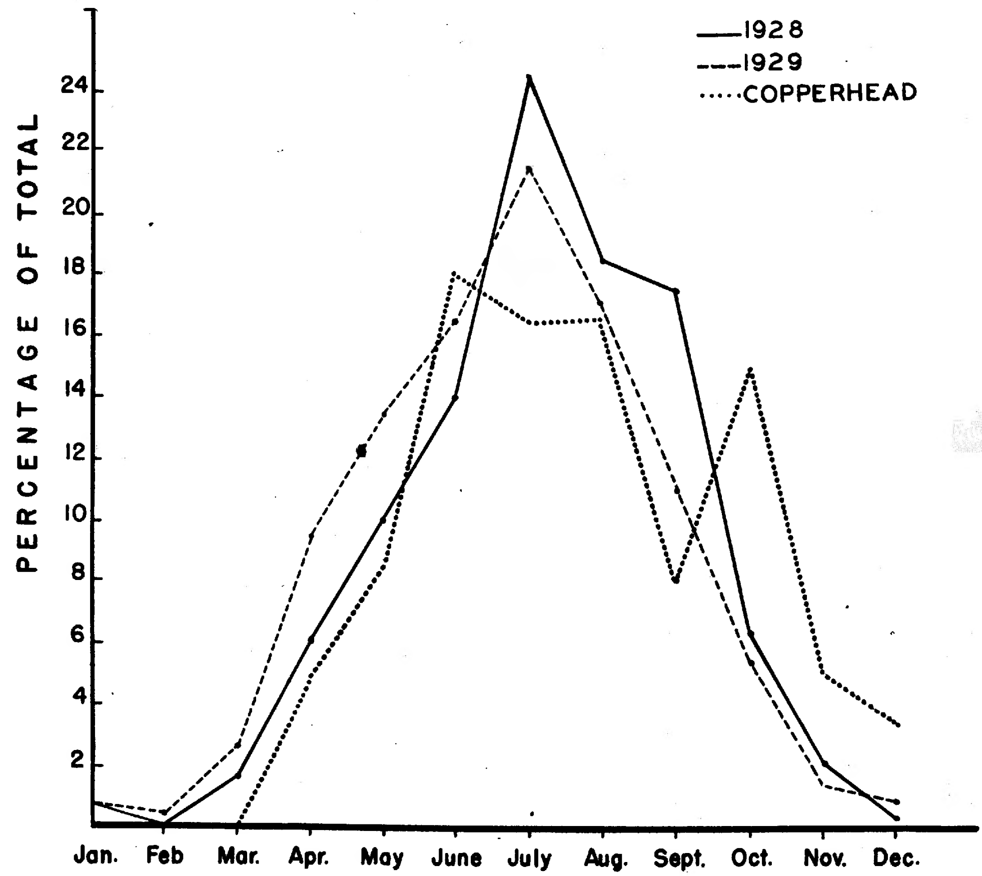


Fig. 4. The monthly occurrence of snake bites recorded in the United States for a two-year period, 1928 and 1929, and the seasonal incidence of the copperhead in the vicinity of Raleigh, North Carolina.

eral factors. Hutchison (1930), discussing the seasonal distribution of the bites, says only that "the information there given is very similar to that for 1928 and emphasizes the relation between temperature and the activity of these Ophidia." The occurrence of the bites suggests strongly that the increased outdoor activity on the part of humans during the summer months is an important factor.

Hutchison points out that the data dealing with the seasonal incidence of snake bites suggest specific differences in regard to the species responsible for the bites. The copperhead (*Agkistrodon mokeson* subspp.) was responsible for more bites than any other single species during the two years under consideration. The only data available for the seasonal incidence of this snake are from Raleigh, North Carolina, and these have been plotted on figure 4. For such a crude comparison there is a surprising degree of similarity between the incidence of this snake in North Carolina and the seasonal occurrence of snake bites. The graph illustrating the seasonal incidence of the copperhead in the vicinity of Raleigh, North Carolina, is also quite similar to that for the pit vipers at Pelotas, Brazil, two localities with the same climatic classification.

Comparison of the graph for the copperhead with that for the total species observed at Raleigh shows that this snake is most abundant one month later than the average peak for all species and that it re-

mains active during the period of decreased activity for the other species in that locality. Conant (*op. cit.*) found that the massasauga (*Sistrurus c. catenatus*) became active later than the other species at Toledo, Ohio. Two of the three species of rattlesnakes studied by Klauber (1931) were found to be active early, whereas the third was late. The data for the venomous species at Pelotas, Brazil, suggest that they may represent late species to judge by the monthly temperature changes. These species also maintain a relatively high incidence throughout the warm months. All of the venomous species mentioned above are crotalids, and they are mainly crepuscular or nocturnal in habits during the warmer periods. These habits may explain in part their departure from the incidence exhibitied by the non-venomous species.

## SUMMARY AND CONCLUSIONS

Data dealing with the seasonal incidence of a Neotropical colubrine snake, *Thalerophis richardi nigromarginatus*, are presented. In the vicinity of Iquitos, Peru, these snakes exhibit a peak of maximum abundance in March, at which time 29 per cent of the total number are recorded. Analysis of monthly fluctuations in numbers suggests that climatic as well as other factors influence the activities of these snakes. The slight variation in mean monthly temperatures, with a range of only 2.4° C., indicates that thermal factors are not the basic cause for the fluctuations.

Rainfall appears to be the most important physical factor influencing the activities of these snakes, although its action is primarily indirect. Two phenomena associated with rainfall and affecting the incidence of the snakes are (1) the abundance of the frogs that constitute their principal food, and (2) the restriction of the dry land areas as a result of widespread flooding during the wet months of the year.

In constrast to the observations on *Thalerophis* are those reported for snakes at localities in the higher latitudes where there are marked variations in monthly temperatures. The extreme fluctuations in temperature bring about a decrease in the incidence of snakes, resulting either in hibernation when the temperatures are low or in estivation when they are high. The studies referred to illustrate a maximum abundance in the spring of the year as soon as hibernation is terminated. This is followed by an almost equally sharp decline in numbers during the warmer, and frequently drier, months. In four of the five studies a small peak of abundance occurs in the fall when the temperatures again approach those prevailing at the time of the spring peak.

Within the limits of the controlling temperatures various factors may influence the monthly fluctuations: (1) aggregation of some species in the vicinity of hibernation dens; (2) mating activity; (3) increased appetite for food following hibernation, and a later decrease in appetite; (4) basking during periods of near-minimal air temperatures; (5) variations in the amount of protective cover provided by deciduous vegetation; (6) change from diurnal to crepuscular or nocturnal habits with an increase in diurnal temperatures; (7) rainfall; (8) seasonal variations in human activity; (9) oviposition; and (10) the appearance of the young of the year.

The monthly maximum for snake bites recorded in the United States occurs from two to three months later than the period of maximum incidence reported at the four localities in the United States. This discrepancy probably can be attributed to the later appearance and more prolonged summer activity of the venomous species responsible for most of the bites, as well as to the increased outdoor activity of humans during the summer months.

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